Effect of Energy Supplementation of Alfalfa Hay or Alfalfa Silage on Protein Supply to Lactating Cows

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Introduction

Ease of mechanization and reduced susceptibility to weather damage have made conservation of alfalfa as silage, rather than as hay, increasingly common. Substantial increases in milk and milk protein secretion from ruminally undegraded protein (RUP) supplementation in cows fed alfalfa silage (AS) diets indicated that intestinal protein supply was limiting. Moreover, response of milk protein secretion to RUP has been shown to be greater for AS than for alfalfa hay (AH) diets (Broderick 1995). Extensive conversion of protein to NPN occurring during silage fermentation results in excessive production of NH_3 in the rumen, suggesting that conservation of alfalfa as silage may reduce ruminal protein escape and (or) synthesis of ruminal microbial CP (MCP) relative to hay. Grinding high moisture corn (HMC) stimulated ruminal in vitro NH_3 uptake and milk protein secretion relative to no treatment of HMC. This suggests that enhancing the availability of ruminal fermentable energy may be an effective strategy for increasing microbial capture of ruminally degraded CP from AS. Measuring excretion of purine derivatives (PD) may provide a convenient method to estimate MCP supply in vivo because: 1) dietary purines are extensively degraded in the rumen and intestinal purines are almost exclusively of microbial origin, and 2) we previously reported (Vagnoni and Broderick 1995) a precise ($r^2 = .93$) linear relationship between PD excretion and intestinal purine flow. Therefore, we evaluated dietary responses of milk protein yield and MCP supply (estimated from PD excretion) to HMC supplementation of AH and AS diets. Specifically, we were interested in whether: 1) milk protein yield increased in response to HMC more on AS than AH diets and 2) whether dietary responses in milk protein yield corresponded to those observed for MCP.

Materials and Methods

Alfalfa silage was chopped to a theoretical length of 1.0 cm and ensiled in a concrete bunker silo at 41% DM. Alfalfa hay was wilted to approximately 85% DM, conserved as small rectangular bales and stored under shelter. Neither hay nor silage was rained on. Twelve multiparous Holstein cows were assigned to three replicated 4 x 4 Latin squares with 21-d periods. Days 1 to 14 of each period served as an adaptation period and all sample and data collection occurred during d 15 to 21. Diets were based on AH or AS and contained (DM basis) 24 or 40% HMC (Table 1). The HMC was ground through a 10-cm screen using a hammermill before mixing in the diet. Total urine collections were made using indwelling Foley catheters and urine output was measured for 3 days. Milk samples also were obtained at the a.m and p.m. milkings for the last 3 d of each experimental period. Ruminal samples were obtained at 0, 4, 8, and 12 h post-feeding for the determination of bacterial CP:purine ratio. Blood samples were taken 4 h after feeding on the last day of each period from the coccygeal artery or vein. Microbial CP flow was estimated using the following equation (Vagnoni and Broderick 1995):

$$\text{MCP, g / d} = \frac{\text{g MCP}}{\text{mmol purine}} \times \frac{\text{mmol /d PD excretion - 130}}{.856} \qquad (1)$$

Results and Discussion

Crude protein content was similar between AH and AS but fiber concentrations were higher in AH than in AS. Consequently, the fiber content was higher and the calculated NE_L content lower in AH than AS diets (Table 1). The high NPN content (56.9%) of AS was in accordance with typical observations in excess of 50%. Dry matter intake increased ($P < .05$) in response to HMC level and to AH versus AS diets (Table 2). Yields of milk and milk protein also increased ($P < .001$) in response to HMC level but were unaffected by forage source. Milk protein yield increased in response to HMC by 100 g/d and 170 g/d on AH and AS diets, respectively (Forage x HMC, P = .091). Assuming that the milk protein response to HMC was mediated principally through MCP supply, these data suggest that the protein status of cows consuming AS diets was poorer (and hence more responsive) than protein status of cows consuming AH diets. Total PD excretion and urinary allantoin:creatinine were increased ($P < .05$) by both increasing HMC level and AH versus AS diets and responded more to HMC on AS than AH diets (i.e., Forage x HMC interaction was significant). Plasma allantoin concentrations were increased in response to HMC level (*P* < .01), and the response was greater on AS than AH diets (Forage x HMC, P = .081). The bacterial CP:purine ratio decreased (P = .01) in response to HMC level and was lower for AH than AS diets (*P* < .001). This ratio is important because it directly influences the calculation of MCP supply (Eqn. 1 above). Estimated MCP supply was increased by HMC level (*P* < .001), more so on AS than on AH diets (*P* = .022); there was no effect due to forage source.

Conclusions

These results indicated that availability of ruminal degradable CP, relative to energy, for MCP synthesis was in excess on AS compared to AH diets. Also, the nature of the response to supplementation of HMC paralleled that for milk protein yield and suggested that PD excretion accurately predicted the response of MCP yield to the diet.

References

Broderick, G.A. 1995. Performance of lactating dairy cows fed either alfalfa silage or alfalfa hay as the sole forage. J. Dairy Sci. 78:320-329.

Vagnoni, D.V. and G.A. Broderick. 1995. Purine derivative excretion by holstein cows abomasally infused with incremental amounts of purines. Research Summaries of the U.S. Dairy Forage Research Center, USDA-ARS, Madison, WI.

Table 1. Composition of diets[1].

Item	AH	AS	AH + HMC	AS+ HMC
	- - - - - - - -	- - - - - - - % of DM	- - - - - - - -	- - - - - - - -
AH	75.0	...	55.0	...
AS	...	75.0	...	55.0
Ground HMC	24.0	24.0	40.0	40.0
Soybean meal	...	...	3.5	3.5
Sodium bicarbonate	...	...	.5	.5
Sodium phosphate	.5	.5	...	...
Dicalcium phosphate	...	...	.5	.5
TMS & vitamins[2]	.5	.5	.5	.5
Chemical composition				
CP	17.0	17.3	16.2	16.4
NDF	35.6	33.0	30.4	28.5
ADF	25.0	23.8	19.9	19.1
NE_L, Mcal/kg DM	1.54	1.60	1.65	1.69

[1]AH = alfalfa hay, AS = alfalfa silage, HMC = high moisture corn, TMS = trace mineralized salt.

Table 2. DM intake, milk yield, purine derivatives, and microbial crude protein supply.

						$P > F$[2]		
Item	AH	AS	AH+HMC	AS+HMC	SE	Forage	HMC	FxHMC
DMI, kg/d	22.8	21.9	24.2	23.5	.4	.044	<.001	.784
Milk, kg/d	29.6	28.2	31.6	31.8	.7	.351	<.001	.262
Milk protein, kg/d	.96	.90	1.06	1.07	.02	.219	<.001	.091
PD excretion, mmol/d	552	473	603	568	11	<.001	<.001	.049
Urinary A:C	3.23	2.75	3.43	3.18	.05	<.001	<.001	.021
Plasma A:C	41.6	39.6	43.2	46.4	1.4	.661	.006	.081
MCP:purine, g/mmol	.604	.713	.570	.666	.001	<.001	.010	.553
MCP, g/d	1981	1925	2081	2262	50	.222	<.001	.022

[1]AH = Alfalfa hay, AS = alfalfa silage, HMC = high moisture corn.
[2]Probability of a significant contrast effect, FxHMC = Forage x HMC interaction.